THE WATER WORKS AT CAMP GRANT[1]

By Charles B. Burdick

Camp Grant, located upon the Rock and Kishwaukee River 5 miles south of Rockford, Ill., is typical of sixteen divisional cantonments constructed to house the National Army. It furnishes accommodations for 36,000 men as originally planned. As completed it provides housing for 42,000 men and 10,000 animals. Each building is supplied with water. Each barrack is accompanied by a lavatory in a separate building also supplied with hot and cold water and equipped with water closets, urinals, wash sinks and shower baths. The buildings total 1520 and cover an area measuring about 3 miles north and south by $1\frac{1}{2}$ miles east and west.

Water supply requirements. The requirements for water supply demanded first, absolute healthfulness, second, adequate fire protection for a rather congested city of wooden buildings, and third, a speed of design and construction that has probably never been equaled for a water supply of the size required.

The instructions to the constructing quartermaster required that water should be provided to the amount of not less than 55 gallons per day per man, or about 2,000,000 gallons per day for the 36,000 men originally proposed for Camp Grant. Instructions further provided that the plant should be capable of delivering water to the distribution system at 2.85 times the above rate, or approximately 5.7 million gallons per day. This was obviously intended to refer to rates for very short periods.

It was required that the water should be furnished under a pressure not less than 60 pounds and not more than 85 pounds unless greater pressures were necessary to distribute the water.

Available supply sources. Northern Illinois is a well watered country and surface supplies are almost everywhere available, but on account of the abundance of ground water, they are seldom used for domestic purposes. A surface water supply at Camp Grant would have been particularly undesirable, even if filtered, on

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account of heavy sewage pollution in the two streams which border the camp. An investigation was made to determine the practicability of purchasing a supply of water from the city of Rockford, but the quantity available was not sufficient.

There are two sources of ground water everywhere available in the northern one-third of the state, namely, the St. Peter sandstone and the Potsdam sandstone. In most of the river valleys it is also possible to develop water sufficient for a municipal supply from the glacial and alluvial sands and gravels.

The St. Peter sandstone is from 150 to 250 feet in thickness, and in Rockford wells to penetrate it completely would be from 400 to 500 feet deep. A part of the Rockford municipal supply is obtained from this source.

The Potsdam sandstone is much thicker, reaching a thickness of upward of 1000 feet at Rockford. It contains numerous veins of water. The top of the Potsdam sandstone is reached locally at a depth of about 500 feet, and wells about 1500 feet in depth usually are required to fully develop this formation.

The blanket of glacial drift overlying bed-rock varies in thickness in the vicinity of Rockford up to 200 to 300 feet in those places in the valley of the Rock River that were eroded by the ancient stream. In these places the St. Peter sandstone lies immediately below the glacial drift. The glacial drift and river alluvium overlying bed-rock largely consist of sand and gravel and are filled with water below the ground-water plane of the region, which is approximately the level of the streams. Water can be withdrawn from the drift in large quantities where the water-bearing stratum has sufficient depth and porosity. In the city of Rockford the drift in many places is thin and uncertain in character to such extent that no large supplies have been drawn from it, the general practice being to enter the underlying sandstone for all large and moderately large water supplies, such as the municipal supply and private supplies for various manufacturing institutions in the city.

All underground waters of the region are excellent from the hygienic standpoint. All three of the available underground waters are, however, moderately hard.

The time available would not permit of an underground reconnaissance by test borings to determine the most practicable place adjacent to the camp to develop a water supply. Knowing that the sandstone would furnish the required water if it could not be de-

veloped in the drift, it was promptly decided to procure well drilling outfits capable of penetrating the St. Peter sandstone, or going even deeper if advisable. It was further decided to select a locality as favorable as possible so far as surface indications went; to keep an accurate log of the drift materials encountered in constructing the wells, and to utilize a supply in the drift should favorable materials be disclosed in the construction of the permanent wells, otherwise to continue the wells into the St. Peter's sandstone.

It was estimated that with good luck, a St. Peter's well would require about six weeks in drilling. It was further estimated that from six to eight wells would be required to supply the camp. Under these circumstances it would not be practicable to supply the camp by September 1 without employing a number of well drilling rigs. Accordingly, arrangements were made for the rental of four deep-well drilling outfits which were placed at work as rapidly as they could be secured, transported and erected.

The wells. The condition of the pipe market was such that material for private work was practically unobtainable, and pipe for use in well casings was obtainable by the government only with great difficulty and delay. It was early recognized, therefore, that well casings must be ordered at once, capable of completing all necessary wells under the most unfavorable circumstances of the underlying formations that would be likely to be developed in construction.

Under the provision of the general contract, the well drilling outfits were rented by the general contractor under a special contract, the general contractor providing all labor and operating and maintaining the drilling outfits. On account of heavy developments in the oil regions, considerable time was required for the delivery of well-drilling repair parts, and to forestall materials required for maintenance, a supply of drills, cables and other equipment was ordered that would probable be worn out in case it was necessary to drill into the sandstone. One well strainer was provided in order that the first well could be tested should favorable materials be disclosed in the overlying drift.

On June 29, an arrangement was closed with F. M. Gray, Jr., to furnish such well drilling rigs as would be required up to a total of five rigs. The first rig was delivered about the middle of July, and closely followed by two others, and on August 1, three rigs were in operation at depths of 71, 62 and 79 feet respectively.

The first well, after passing through the surface alluvial soil, had entered sand and gravel which continued to a depth of about 90 feet; then the drill passed into clay to 115 feet; then into quicksand and clay to a depth of 135 feet, and then into good coarse water-bearing sand to a depth of 156 feet below the surface. At this point the conditions were deemed sufficiently favorable to insert a strainer and test the well. This was immediately done, and on August 13 the well was tested, producing 311 gallons per minute with a drawdown of 13 feet. It was then decided to develop the drift water supply in the remainder of the wells should equally favorable conditions be found. Favorable materials being encountered three wells were completed during the month of August and two additional wells in September. The last of the six wells was completed October 25.

TABLE 1

Specific capacity of individual wells

WELL NUMBER	PUMPAGE RATE IN GALLONS PER MINUTE	DRAW-DOWN BELOW STATIC WATER LEVEL, FEET	SPECIFIC CAPACITY, GALLONS PER MINUTE PER FOOT OF DRAW-DOWN
1	311	13.0	23.
3	225	10.0	22.5
4	299	8.1	36.8
5	263	10.75	25.
6	286	6.42	44.5
7			18.0

All wells are equipped with Johnston strainers having a No. 40 slot. Four strainers are 10 inches in diameter and 16 feet long. Two strainers are 20 feet long and 8 and 10 inches in diameter respectively.

As is the case with all wells in granular materials such as sand and gravel, the practicable rate of pumpage is directly proportional to the depression of the water surface in the well incident to pumping.

All the 10-inch wells are equipped with 5-inch air lift pumps and pipes having an economical capacity each of 500 gallons per minute. The specific capacities of the wells vary somewhat, but the variation in capacity is taken up in different amounts of drawdowns in the several wells. The original tests of the several wells are given in table 1.

As above stated, the capacity of each well, as developed, is lim-

ited by the air lift installation, and it would be possible, if need be hereafter, to increase the capacity of the well system by installing larger air lift pumps. With the present compressor outfit the plant has shown its ability to produce water at the rates given in table 2.

The lift under which the wells operate varies with the amount of water produced, and varies somewhat in the different wells. Measured from the water surface in the well when operating up to the discharge head, the lift varies from 40 to 50 feet, and averages 42 feet when five wells are in operation furnishing the water supply for the present camp, amounting to about 2,300,000 gallons per day.

The wells were spaced at intervals of 300 feet on centers in order that there may be a minimum of interference, particularly having in

TABLE 2

Capacity o well groups

NUMBER OF COMPRESSORS IN SERVICE	NUMBER OF WELLS IN SERVICE	WATER PRODUCED GALLONS PER MINUTE	GALLONS PER MINUTE PER WELL
1	3	1,376	459
1	4	1,525	381
1	6	2,160	360
2	5	2,470	494
3	5	2,656	531
2	6	2,740	457
3	6	3,300	550

mind the possibility that it might be necessary to go to the Potsdam sandstone for a water supply. The percentage of interference, that is to say, the delivery per foot of draw-down of the group of wells as compared to the sum of the capacities of single wells added together, is approximately 77 with five wells in service. This percentage varies slightly, depending upon the individual wells in service.

Elastic development required. As no time was available to sink test wells and pump them, it was necessary to assume the underground conditions as accurately as possible and to adopt pumping devises that would be workable under any conditions likely to be disclosed in the construction of the works.

Accordingly, it was decided to adopt double pumping, and in view of the possibility that St. Peter's wells would be used, it was

deemed advisable to install an air lift pumping system of sufficient capacity to lift the water, at the demanded rates and height, 100 feet if necessary. At the same time the design was worked out so that it would be reasonably well adapted for pumping a smaller quantity of water against as high a head as 150 feet, or a greater quantity of water against a head of 50 feet or even less.

This general plan of development seemed economical under the circumstances because the probable temporary nature of the supply made it desirable, as a general principle, to pump a few wells to a considerable depth rather than a large number of wells to a less depth. Furthermore, there is probably no means for pumping well water that is more reliable in its operation and that is less likely to derangement than the air lift pump.

For the above reasons the air lift was adopted for Camp Grant. It was decided to install three air compressor units, each capable of pumping 1000 gallons per minute against a total head of 100 feet. This would allow a development of 2000 gallons per minute with one machine in reserve. In the development of the water supply from the drift under a less head, the pump capacities of the compressors are proportionately increased, as indicated by the figures of yield previously shown.

A canvass of the power situation disclosed a very good central generating station in Rockford privately owned, with the practicability of purchasing power on a sliding scale rate. The necessity for a quickly installed plant and the probability of very reliable service from the Rockford installation led to the very early decision to utilize electric power in the water works pumping operations.

As a reserve for use in case the electric power should be temporarily unavailable, an oil engine was installed which could furnish the camp with water for a short time. This pumping unit proved to be very valuable, for it enabled the plant to begin pumping operations about a weak earlier than would have been possible with electric power.

Pumping equipment. Electrically driven centrifugal pumps were adopted for the high lift equipment on account of the rapidity with which they could be furnished, transported and installed. Stock apparatus was used for part of the equipment. The low installation cost per unit of capacity also made this equipment highly desirable in a pumping plant of a more or less temporary nature.

The drilling of the wells, the construction of the concrete reser-

voir and the foundations for the pumping station equipment were begun simultaneously about the middle of July.

The first pumping unit, the oil engine and its pump, was set upon its foundations about August 20, and began pumping on August 25. At this time the building foundation wall only had been completed, and to prevent damage from the weather, the engine flywheel and the belt were covered with a shed constructed of boards and building paper which protected the apparatus until the building was under roof. The air compressors were installed during the last week in August and the first compressor began pumping September 1. The first electric driven pump went into service August 31.

When pumping operations began, the filling around the reservoir was not entirely completed, and the plant started with about 5 feet of water in the reservoir. This was gradually increased as the embankment was completed.

Storage of water. A storage reservoir was adopted intermediate between the low lift and high lift pumps, in order that the well system might be operated as nearly at a uniform rate as possible, thus providing a surplus of water so that the high lift pumps might follow the fluctuating rates of water consumption. This reservoir also serves as a reserve which can be drawn upon for fighting fires. A circular concrete reservoir 16 feet deep containing 300,000 gallons was built for this intermediate storage.

While the average water consumption of the camp should not much exceed 2,000,000 gallons per day, the rate of use at certain hours will probably greatly exceed the ordinary uses of a city, for the reason that all inhabitants of the camp will be subject to the same rules as to the time of arising in the morning, meal hours and going to bed at night. For this reason the use of water, particularly at meal times, is very great, reaching as high a rate as 6,000,000 gallons in twenty-four hours.

In order that these reasonable fluctuations in demand may be taken care of without an excessive installation of machinery, pipes and water supply, it was thought to be desirable to install an elevated tank which, during the peak of the water demand, can feed the system from the center, thus more than doubling the available capacity of pumping machinery and distribution pipes.

Accordingly, a contract was entered into about July 10 with the Chicago Bridge and Iron Works for furnishing and erecting an elevated tank of 300,000 gallons capacity, 140 feet high, from plates in

stock. This company agreed to complete its work by September 15, and it was, therefore, expected that it would be necessary to operate the water supply by direct pressure for about two weeks. The tank was delivered on the ground and erection started on July 28, and by the use of a double force and work during practically all of the daylight hours, the erection was completed on August 20, five days in advance of the completion of the pipe line which permitted the delivery of the water to the camp.

Distribution system. It was early appreciated that the water distribution system, involving 16 miles of mains and 20 miles of service pipes, would require a very prompt delivery of materials and concentrated work to permit supplying water to the troops on September 1. For numerous reasons it was decided at Washington that so far as possible the water pipes should be made of wood.

The wood pipe originally reserved for Camp Grant was rejected and the order cancelled. A rush order for wood pipe was then placed with Pacific Coast mills, and to expedite construction about half the order for 10-inch pipe was placed with cast iron pipe factories and shipped from Scottdale, Pa. Later, to facilitate construction, an additional order was placed for about 3700 feet of 10-inch cast iron pipe shipped from Ohio, and still later, authorization was granted to purchase 10,000 feet of 8-inch cast iron pipe to be shipped from Ohio stock to hasten the completion of the pipe lines.

The valves and hydrants reserved for Camp Grant were provided with the standard bell ends common in water works practice. The wooden pipe reserved for this camp was connected by means of a tenon and a double hub coupling, the tenon being driven into the hub of the coupling. Where special fittings or valves were connected to wooden pipes, or where wooden pipes were connected to iron pipes, a special form of fittings was necessitated. The manufacturer with whom the original pipe order was placed, recommended cast iron fittings with machined hubs of such size as to fit the tenon on the wood pipes, and fittings of this kind were specially made for the work.

Upon the delivery of the wooden pipe from the Pacific Coast it was found that the tenons were too small to make a tight joint in the machined hubs purchased to use with the wood pipe originally ordered. This difficulty was overcome by sawing off the spigots upon certain of the pipe and cutting a new spigot on the ground

after unwinding a few strands of the banding. Later in the work it was found that a passable joint could be made with a standard water pipe fitting without machining, and a large number of such joints were used.

The lack of water pipe during July and the early part of August made it possible to concentrate the work of the trenching machines on sewer pipe laying. Early in August, however, when the sewers were nearing completion, it became necessary to utilize a part of the trenching machines on water pipe, and accordingly, several miles of water pipe ditches were opened, and stood open until pipe arrived.

The first water pipe reached Camp Grant August 14. Considerable difficulty had arisen in holding experienced pipe layers on account of the delayed delivery of the pipe, but as rapidly as possible, the gangs were reorganized. On August 25, the pipe line between the pumping station and the elevated tank, about 6000 feet in length, was completed, and the water was turned in. Since this date the camp has been continuously supplied.

On August 31, pipe lines with attached hydrants had been extended through the northwest and southwest wings of the camp, and moderately good fire protection was afforded to every part of the camp where buildings were completed. On this date, 6 miles of water mains were in place, and 5 miles of water service pipes. By September 12, about 70 per cent of the pipe laying had been done, and shortly after the middle of the month there only remained to lay the pipe supplying the stables, not then authorized, and the additions to the camp occasioned by the remount station and the training battalion. This work was completed during the very unseasonable month of October.

Difficulties. It must not be assumed that the work was carried through without difficulties or disappointments. This was far from the facts. Although everyone tried to anticipate difficulties and provide for them in advance, there were few days during the first six weeks when something wholly unexpected and detrimental to progress did not arise. Space will not permit recording them here, but they were real difficulties at the time, and that some of them did not defeat the purpose of the work is due to the superintendents and foremen, who displayed great resourcefulness in emergencies.

Early in the work, before everyone's powers and duties were clearly understood, there was much in the way of chasing up blind

alleys and coming out again before the right path was found. The good nature displayed by everyone in these encounters was surprising. In fact, it was a feature of the work from first to last, that in case of error everyone searched for the remedy rather than a "goat" to place the blame upon, and it was this spirit among the men engaged that made this strenuous work a pleasure.